

# PATENT SPECIFICATION

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## (54) IMPROVEMENTS IN OR RELATING TO PLATE HEAT EXCHANGERS

(71) We, THE A.P.V. COMPANY LIMITED, a British Company of P.O. Box. No. 4 Manor Royal, Crawley, Sussex RH10 2QB, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to plate heat exchangers.

A plate heat exchanger normally comprises a pack of plates arranged in spaced face-to-face relationship to form flow spaces between adjacent plates. The flow spaces are bounded by peripheral gaskets on the plates. Supply and discharge of heat exchange media are through supply and discharge ports defined by aligned apertures in the plates, and gasketing is arranged so that alternate flow spaces connect the supply and discharge ports for one medium and the intervening flow spaces connect the supply and discharge ports for the other medium. In order to create turbulence in the flow spaces to increase the heat transfer, the plates are usually provided with ribs and troughs which in some cases intermate to provide an undulating flow path, but in the type of exchanger to which the present invention relates, they cross and abut to provide a flow region with turbulence created by continued sub-division and commingling of the flow, and with closely spaced points of abutment of adjacent plates whereby good interplate support is achieved so that the heat exchanger can be used with comparatively high operating pressure.

40 It is well understood that if the corrugations are steeply inclined to the general flow direction along the plate, the plate will have a high heat transfer characteristic and a high pressure drop, i.e. it is termed a hard plate, whereas as the inclination de-

creases so do the heat transfer and pressure drop, i.e. the plate becomes softer.

It will be appreciated that since the port-forming apertures are normally near the corners of generally rectangular plates, an important function of the zones adjacent the apertures is to distribute the medium across the full width of the plate and to act as a collector to return the fluid to the discharge port.

The flow passage between the ports is by no means uniform in width and in particular where the flow ports are on the same side of the plate, the variation in the effective length of the flow path at different points across the width of the plate results in uneven distribution which can affect plate performance. At the same time it is important that the plates be protected, by interplate support, from distortion in these areas.

It has hitherto been the general practice to have the same form of corrugation in the main heat transfer area in the top and bottom transitional zones, but it has recently been recognised that the different functions of the main heat transfer area and transitional zones might merit the adoption of different formations. To achieve good distribution over the width of the plate, it is important that the pressure drop down the transitional zone is low compared with that down the main heat transfer zone, so that the effect of the variation in flow path length is minimised. Further the transitional zone should allow the maximum degree of transverse flow in order to assist in distribution.

According to one aspect of the present invention, there is provided a plate heat exchanger comprising a pack of ported, separable, gasketed plates in spaced face-to-face relationship, each plate comprising a principle heat exchange zone provided with turbulence-promoting corrugations

crossing and abutting the corresponding turbulence-promoting corrugations on the adjacent plates, and transition zones between the ports and the principal heat exchange zone, the transition zones being formed with a pattern of dimples abutting the transition zones of the adjacent plates to provide interplate support, the dimples being so shaped and spaced that no straight line can be drawn along the surface of the plate in the transition zone except possibly for areas at the apices of the dimples.

According to another aspect of the invention, there is provided a ported and gasketable plate for a plate heat exchanger, comprising a principal heat exchange zone provided with turbulence-promoting corrugations of a constant height adapted to cross and abut with corresponding corrugations on a plate of similar type arranged adjacent thereto in a pack, and transition zones between the principal heat exchange zone and the ports, the transition zones being formed with a pattern of dimples of the same height as the corrugations adapted to abut corresponding dimples in the transition zones of adjacent similar plates to provide interplate support, the dimples being so shaped and spaced that no straight line can be drawn along the surface of the plate in the transition zone except possibly for areas at the apices of the dimples.

The dimples will normally be provided so as to extend alternately in opposite directions.

Preferably, the dimples are arranged so that the spacing between contact points in the transition zones is similar to the spacing between contact points in the principal heat exchange zones.

Since a dimple formation is inherently somewhat more resistant to deformation than a corrugation, the pitch of the dimples can be slightly greater than, although still of the same order as, the pitch of corrugations crossing points to give the same resistance to distortion under differential pressure. This leads to a reduced pressure loss, with improved distribution, for the same strength as the principal heat exchange zone.

The invention will be further described with reference to the drawings accompanying the provisional specification and the accompanying drawings.

In the drawings accompanying the provisional specification:—

Figure 1 is an elevation illustrating the principal features of a typical heat exchanger plate,

Figure 2 is a view similar to Figure 1, showing a form of plate according to the present invention;

Figure 3 is an enlarged section through two adjacent plates on the line W-W of Figure 2;

Figure 4 is an enlarged section through two adjacent plates on the lines X-X of Figure 2;

Figure 5 is an enlarged elevation of a portion of Figure 2;

Figure 6 is a section through two adjacent plates on the line Y-Y of Figure 5. 75

Figure 7 illustrates diagrammatically the method of pressing the dimples zones; and

Figure 8 illustrates diagrammatically a method of cutting the tools for pressing the dimples zones. 80

In the accompanying drawings:

Figure 9 is a view similar to Figure 2 showing a modified form of plate; and

Figure 10 is a further similar view showing a further modified form of plate. 85

In Figure 1 a plate 1 has an inlet port 3, an outlet port 4, and a peripheral seal or gasket 2, surrounding both the ports 3 and 4 and surfaces A, B and C. Surfaces A and C are generally triangular transition zones whilst surface B is a rectangular principal heat exchanger area. Surface A provides for diffusion of the incoming liquid from port 3 by deceleration whilst C performs the reverse function in directing 90

the outgoing liquid to the exit port 4 and it is desirable that restriction to fluid change of direction is minimised on these surfaces. The liquid may flow in the opposite direction, i.e. entering at port 4 and leaving via port 3 requiring that surfaces A and C be identical but reversed to create identical effects on the fluid flow from either direction. The surface 'B' provides for the transmission of heat through the 105 plate. There are well known means of creating turbulence in this section by impressing corrugations into the plate as shown in Figure 2.

Figures 3 and 4 shows the corrugations 110 5 of one plate inclined to the corrugations 5 of the adjacent plate such that the roots 6 of one plate cross and abut the crests 7 of the next plate. The points of contact are indicated 'P' and there are similar points of contact, Q, with the abutting plate (not shown). By selecting the pitch and shape of such troughs the contact points may be

of a desired number for a unit area of surface. Although the corrugations have been shown an angular, it will be appreciated that these are pressed in metal and hence are in practice more rounded than illustrated and the points of contact P and Q will be of comparatively small area. 115

Figures 3 and 4 shows the corrugations 120 5 of one plate inclined to the corrugations 5 of the adjacent plate such that the roots 6 of one plate cross and abut the crests 7 of the next plate. The points of contact are indicated 'P' and there are similar points of contact, Q, with the abutting plate (not shown). By selecting the pitch and shape of such troughs the contact points may be

of a desired number for a unit area of surface. Although the corrugations have been shown an angular, it will be appreciated that these are pressed in metal and hence are in practice more rounded than illustrated and the points of contact P and Q will be of comparatively small area. 125

In such corrugations, as shown in Figure 4, the ridge is normally continuous in the vicinity of the points of contact. This continuity can be arranged to have a directional effect of the flow stream which is 130

beneficial in creating turbulence but is to be avoided in diffusion.

Figures 2, 5 and 6, show that the transitional zones are formed with a pattern of dimples 8 extending alternately in opposite directions to abut the dimples 8 on the adjacent plate. Figure 5 is an enlarged elevational view of part of one of the triangular transition zones A, C of the 10 Figure 2 form of plates and Figure 6 shows the abutment of the dimples 8. Although it might appear from the diagrammatic drawing in Figure 5 that common tangents to the circles indicating the 15 dimples could be drawn in the plane of the plate, it will be appreciated that in practice the dimples tend to merge to such an extent that the plates do not have any plane areas on which straight lines can be drawn, 20 except possibly for small flat areas at apices of the dimples.

The surfaces adjacent to the fluid entry and exit ports are provided with a pattern of dimples such that the number of contact 25 points per unit area is approximately similar to that in the ridged sections but the flow directionality is reduced. The number of contact points per unit area may in fact be somewhat less than that in 30 the ridged sections which maintain the same strength, as a result of the inherently greater strength of dimples when compared with ridges. The shape and spacing of the dimples is such that in these transitional 35 regions, no straight line can be drawn along the surface of the plates. This avoids lines of weakness on which the plate would be especially liable to bend under pressure.

The plates are normally manufactured 40 by pressing and Figure 7 shows a sheet of metal 10 being pressed between two tools 11 each including a plurality of projections 12. The conventional process of forming the projections 12 as pins added to the 45 tools would be very costly for a large number of projections e.g. four per square inch, as is envisaged, and consequently the tools are manufactured by machining grooves out of a solid block to leave projections at 50 the unmachined parts. This can be achieved by machining grooves of a width and position to suit the required pattern of dimples. By reference to Figure 8 for example, machining grooves along the four 55 sets of lines marked D-D would result in an octagonal faced projection which is repeated at equal intervals of distance in directions E-E and F-F. The machine cutter outline is designed to ensure that the 60 projection profiles are contoured to avoid splitting of the sheet metal being pressed.

In the accompanying drawings, a plate 1 is shown in Figure 9 as having the corrugations in the principal heat exchange 65 zone 5 in a herring bone formation formed

by two zones 5a and 5b with corrugations in opposed or mirror image arrangement. In Figure 10 there are four zones forming a W formation of the corrugations. It will be appreciated that numbers other than 2 70 or 4 may be used, but the mirror image arrangement will only normally be achieved if even numbers of zones are used.

Various modifications may be made 75 within the scope of the invention.

#### WHAT WE CLAIM IS: —

1. A plate heat exchanger comprising a pack of ported, separable, gasketed plates in spaced face-to-face relationship, each plate comprising a principal heat exchange zone provided with turbulence-promoting corrugations crossing and abutting the corresponding turbulence-promoting corrugations on the adjacent plates, and transition zones between the ports and the principal heat exchange zone, the transition zones being formed with a pattern of dimples abutting the transition zones of the adjacent plates to provide interplate support, the dimples being so shaped and spaced that no straight line can be drawn along the surface of the plate in the transition zone except possibly for areas at the apices of the dimples.

2. A ported and gasketable plate for a 95 plate heat exchanger, comprising a principal heat exchange zone provided with turbulence-promoting corrugations of a constant height adapted to cross and abut with corresponding corrugations on a plate 100 of similar type arranged adjacent thereto in a pack, and transition zones between the heat exchange zone and the ports, and the transition zones being formed with a pattern of dimples of the same height as the corrugations adapted to abut corresponding 105 dimples in the transition zones of adjacent similar plates to provide interplate support, the dimples being so shaped and spaced that no straight line can be drawn along 110 the surface of the plate in the transition zone except possibly for areas at the apices of the dimples.

3. A plate heat exchanger as claimed in claim 1, in which the dimples in the transition zone are so spaced that the interplate support provided is similar to that provided by the crossing and abutting of the corrugations in the principal heat exchange zones.

4. A plate or plate heat exchanger as claimed in claim 1, 2 or 3, in which the dimples extend alternately in opposite directions.

5. A plate heat exchanger as claimed in claim 1, 3 or 4, in which the dimples are arranged so that the spacing between contact points in the transition zones is similar to the spacing between contact points in the principal heat exchange zones.

6. A heat exchanger or plate as claimed in any of the preceding claims, in which the principal heat exchange zone has the corrugations arranged in a herring-bone formation.
7. A heat exchanger or plate as claimed in any of claims 1 to 5, in which the principal heat exchange zone has the corrugations arranged in a series of longitudinal sub-zones, with the corrugations in alternate sub-zones being parallel.
8. A heat exchanger or plate as claimed in claim 7, in which the corrugations in adjacent sub-zones are mirror images of each other.
9. A plate heat exchanger substantially as hereinbefore described with reference to
- the drawings accompanying the provisional specification.
10. A plate heat exchanger as claimed in claim 9, modified substantially as described with reference to the accompanying drawing.
11. A heat exchanger plate substantially as described with reference to the drawings accompanying the provisional specification.
12. A plate as claimed in claim 11, modified substantially as described with reference to the accompanying drawing.

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2 SHEETS

PROVISIONAL SPECIFICATION

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SHEET 1

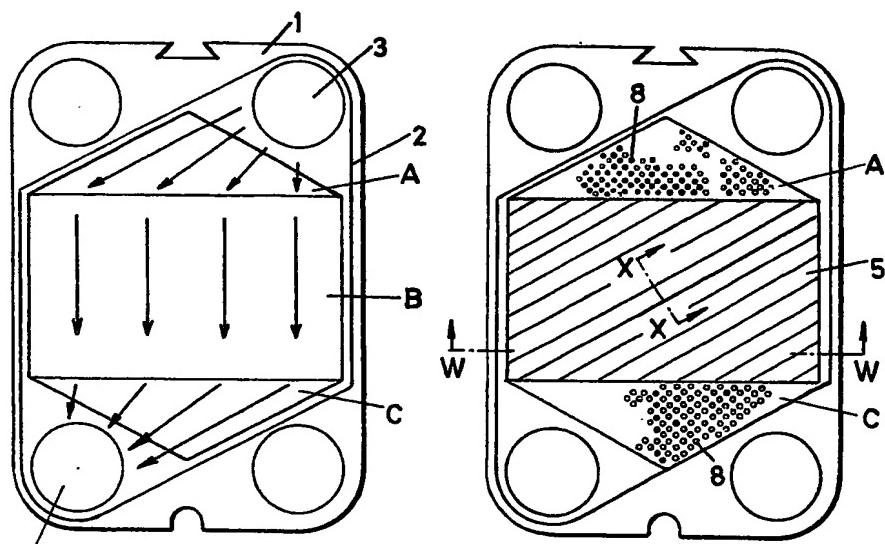


FIG. 1.

FIG. 2.

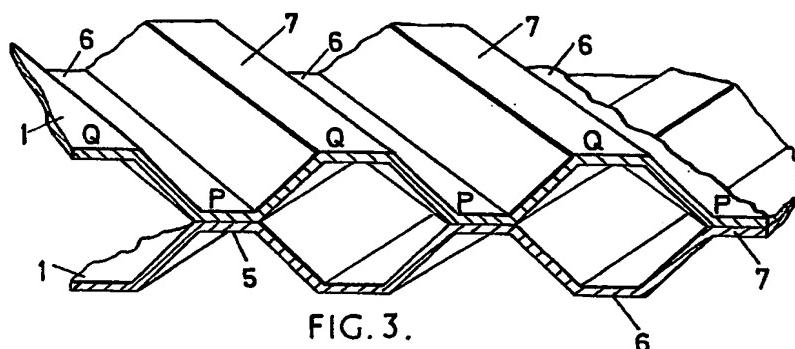


FIG. 3.

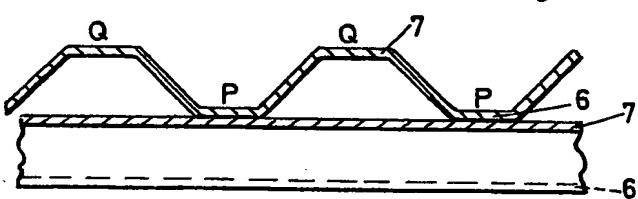


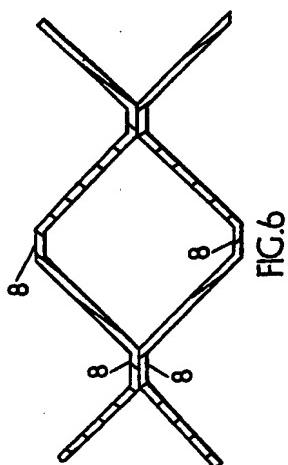
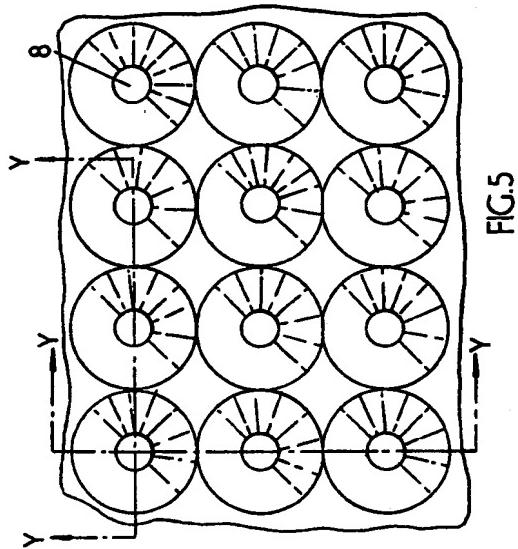
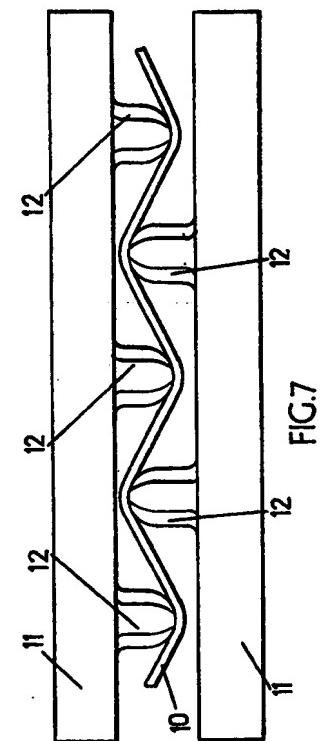
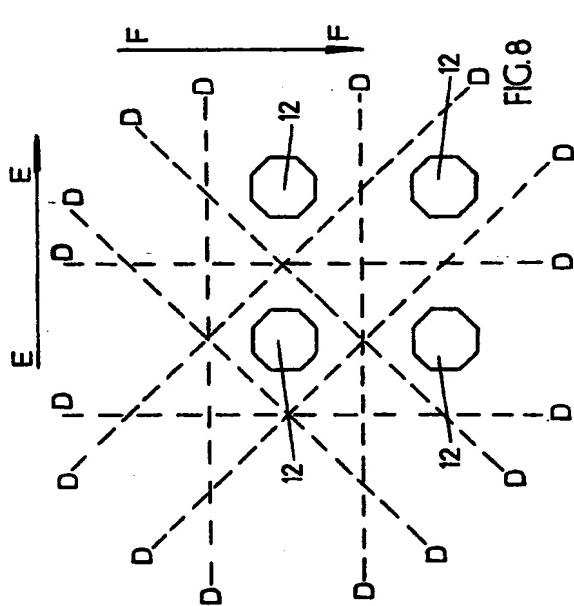
FIG. 4

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2 SHEETS

**PROVISIONAL SPECIFICATION**

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1468514 COMPLETE SPECIFICATION

1 SHEET.

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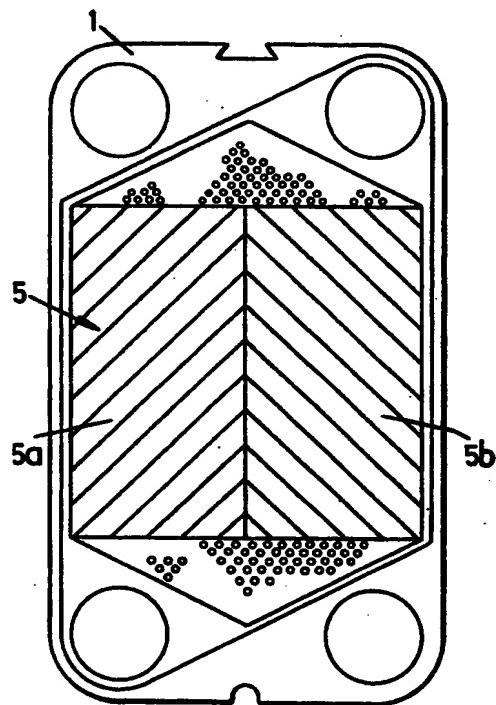


FIG.9

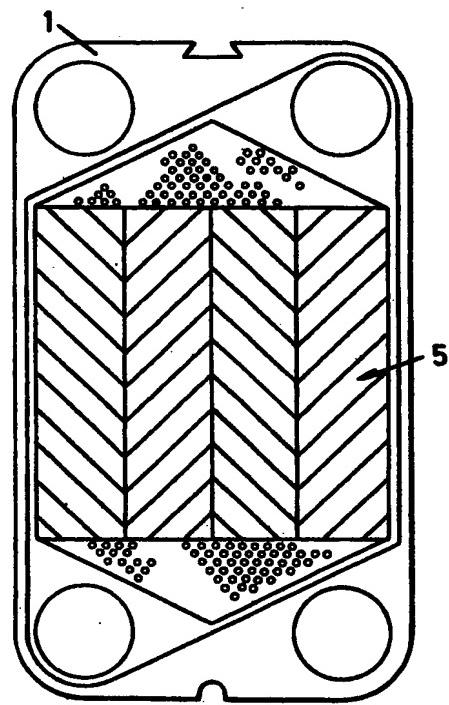


FIG.10

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